Opinion

From Big Science to "Deep Science"

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Abstract

The Standard Model of particle physics has accomplished a great deal including the discovery of Higgs boson in 2012. However, since the supersymmetric extension of the Standard Model has not been successful so far, some physicists are asking what alternative deeper theory could be beyond the Standard Model? This article discusses the relationship between mathematics and physical reality and explores the ways to go from Big Science to "Deep Science".

Keywords: Particle physics, Standard Model, mathematics, physical reality, Big Science.

> *There are more things in heaven and earth, Horatio, Than are dreamt of in your philosophy.* - Hamlet (1.5.167-8), Hamlet to Horatio

Introduction

It was said that young Einstein received a mathematics book from a medical student with the witty remark that "*Mathematics is like catching a mouse; you run after the mouse until it runs into a corner of the room. Then you get it*."

Einstein's mental process was probably shaped along this line of thought. Einstein wrote three important papers in Einstein's miraculous year of 1905, one of the papers being on light quanta and another being the special relativity theory. These three papers have been regarded as the cornerstone of modern physics. However, one may still ask the question: how effective is mathematics when describing physical reality?

Beyond Platonic World

The question of effectiveness of mathematics in physical sciences has been discussed by many physicists, notably Eugene Wigner [1]. Perhaps it is true that mathematics is "the art of catching a mouse". But many physics problems are so delicate that the situation may be more analogous to how to catch a black mouse in a dark room.

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While most physicists believe that they can "catch the mouse" with the latest development in mathematics, there are others who think that there are problems with relying too much on mathematics.

Derek Abbott argues that [3]:

> Mathematical Platonism is an inaccurate view of reality. Instead, he argues for the opposing viewpoint, the non-Platonist notion that mathematics is a product of the human imagination that we tailor to describe reality.
> …
> So if mathematicians, engineers, and physicists can all manage to perform their work despite differences in opinion on this philosophical subject, why then does the true nature of mathematics and its relation to the physical world really matter?
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> The reason, Abbott says, is that when you recognise that math is just an abstract mental construct—*just an approximation of reality that has its frailties and limitations, and that such abstractions will break down* at some point, because perfect mathematical forms do not exist in the physical universe—then you can see how ineffective math actually is.
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> That is Abbott's main point (and the most controversial one): that mathematics is not exceptionally good at describing reality, and mathematics is definitely not the "miracle" that some scientists have marvelled at. Einstein, a mathematical non-Platonist, was one scientist who marvelled at the power of mathematics. He asked, "How can it be that mathematics, being after all, a product of human thought, which is independent of experience, is so admirably appropriate to the objects of reality?
> (*Emphasis added*)

The above quoted text gives us some clues regarding how we should think of mathematics. Yes, mathematics is useful for numerous problems, but as with human being himself, it is bound to limitations, contradictions etc. This problem of mathematical consistency has been discussed bluntly in Godel's famous incompleteness theorem[1].

In other words, we should continue being humble, provided we accept such a non-Platonic view of mathematics. Even if sometimes our theory gives out a series of correct predictions, it does not necessarily mean that we already hit the jackpot of physical reality. But the problem is more acute, because numerous theoretical physicists hold a position which may resemble the following joke:

> *An engineer considers that his/her equations approximate reality,*
> *A theoretical physicist considers that reality approximates his/her equations,*
> *A mathematician doesn't care about reality.*

[1]See for instance Mark Buchanan, Nature, https://www.nature.com/articles/nphys550

It seems that many physicists hold the mathematician's viewpoint of reality, in their stubborn adherence to mathematical models, as if the models themselves hold all the answers. This behaviour happens with the Standard Model of particle physics and with the standard model of cosmology. If there are new observational findings which contradict those standard models, they are discarded, or new words are used to describe the difficulties of the apparent mathematical situation such as "dark energy", "dark matter", and numerous "ghosts" here and there, as mental deflections. Such deflection has become quite the norm in "Big Science."

One scientist[2] once wrote an email to the first author stating that many physicists tend to forget that what they are working with are only models, *i.e.*, approximate and tentative descriptions of physical reality, such as Standard Model of Particle Physics and Standard Model of Cosmology and so on.

In retrospect, perhaps the root cause of such a strict adherence to those models could be traced back to blind acceptance of Einstein's photon model and his special relativity theory. A deeper look into those two theories will reveal that they may be problematic. For example, special relativity theory rejects the notion of ether.

Scaffold to the Moon

There is another philosophical question related to Platonic view: *Do we live in a mathematical universe?* Although this question appears simple, the answer is not. Beyond the Platonic and non-Platonic views, as we discussed above, there is a variety of other possible answers. To mention a few:

- Neo-Platonic view; for example the dodecahedron universe model by Luminet et al.
- number theoretic model of universe (from Pythagoras: "The world is a number".)
- set theory view
- geometric view
- string theory inspired models
- adhesion universe model
- Voronoi tessellatice model
- cellular model, e.g. Konrad Ranzan [9];
- soliton model, e.g. our recent paper on the cellular automaton KdV model (see Appendix);
- nonlinear cosmology based on Kolmogorov's turbulence[3] or Pfaffian turbulence theories [8];

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2 cf. the late Prof. Robert M. Kiehn from Houston University.

3For instance, in few previous papers, we reported our exploration on an early Universe model with rotation. As per our summary report submitted to J. Mathematics (MDPI), we suggest among other things:
"Questions regarding the formation of the Universe and what was there before the existence of the Early Universe have been of great interest to mankind of all times. In recent decades, the Big Bang as described by the Lambda CDM-Standard Model Cosmology has become widely accepted by the majority of physics and cosmology communities. Among other things, we can cite A.A. Grib & Pavlov who pointed to problems with assumptions of heavy particles creation out of vacuum and also launched other proposal such as *Creatio Ex-Nihilo theory* (CET).

So, which one to choose? Our opinion is: you can start with a few assumptions which you find convenient with, and work them out seriously. But after your paper has been published, keep on being flexible, keeping in mind other possibilities.

There are a number of analogies which advise us to remain humble in our journey to decipher the hidden layers of physical reality, *e.g.*, the story of an elephant and five blind men, which you may have heard before. And there is also a Confucius saying: "*The wise man points his finger to the moon, but the fool only sees the finger, not the moon."*[4] The message here is striking: our given theory is only the pointing finger. Yes, the theory surely helps us to see the moon (the Universe), but we should not forget that the theory is not really the Universe.

In a reader doesn't like Zen koans, alternatively there is another analogy held by Murray Gell-Mann, *e.g.*, that his theory helps him like a scaffolding, in order to describe certain physical phenomena. After the work is done, the scaffolding may be not necessary anymore.

One can develop one's theories to be more and more accurate in order to explore the hidden realities of Nature. One may consider this approach as "a scaffold to the moon":

(a) When one's equations have been confirmed by observations and experiments, *Voila!* Yes, it is normal that the first thing that comes to your mind is to celebrate the confirmation of the equations with champagne or a bottle of vodka. An accumulation of such self-celebrating non-physical "experimental confirmations" of mathematical abstractions, leads to *Big Science*.

(b) But that is only the first in the iteration of steps up the scaffold. Perhaps one or two years later, one figures out that there were too many assumptions or there were logical flaws in one's equations, and one must find a better and simpler way to figure out the hidden structure of Nature. That is *Deep Science*. Feynman once remarked something like: "the faster we find out

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But the philosophical problems remain, as Vaas pointed out: Did the universe have a beginning or does it exist forever, i.e. is it eternal at least in relation to the past? This fundamental question was a main topic in ancient philosophy of nature and the Middle Ages. Philosophically it was more or less banished then by Immanuel Kant's *Critique of Pure Reason*. But it used to have and still has its revival in modern physical cosmology both in the controversy between the big bang and steady state models some decades ago and in the contemporary attempts to explain the big bang within a quantum cosmological framework.

Interestingly, Vaas also noted that Immanuel Kant, in his *Critique of Pure Reason* (1781/1787), argued that it is possible to prove both that the world has a beginning and that it is eternal (first antinomy of pure reason, A426f/B454f). As Kant believed he could overcome this „self-contradiction of reason" („*Widerspruch der Vernunft mit ihr selbst*", A740) by what he called „*transcendental idealism*", the question whether the cosmos exists forever or not has almost vanished in philosophical discussions.

It turns out that Neutrosophic Logic is in agreement with Kant and Vaas's position, it offers a resolution to the long standing disputes between beginning and eternity of the Universe. In other words, in this respect we agree with Vaas: "how a conceptual and perhaps physical solution of the temporal aspect of Immanuel Kant's "*first antinomy of pure reason*" is possible, i.e. how our universe in some respect could have both a beginning and an eternal existence. Therefore, paradoxically, *there might have been a time before time or a beginning of time in time*."

To summarize, Neutrosophic Logic study the dynamics of neutralities. And from this viewpoint, we can understand that it is indeed a real possibility that the Universe has both *an initial start (creation) but with an eternal background*."

[4] "*When a wise man points at the moon the imbecile examines the finger."* — Confucius.

flaws in our theory, the better, because it will lead us to move one step forward."

Deep Science is quite comparable to Deep Learning, *i.e.*, the merging of Machine Intelligence and Big Data. This kind of merging becomes crucial in studying physical phenomena, because the amount of data involved in physical science is getting very large.[5] For example, one or two decades ago, a PhD student in astronomy may have needed to analyse a few Gigabytes of data, but these days the data requirements have reached Terabyte levels. In the same way, it is not enough to find the logical structures while studying cosmology. We should also learn physical patterns. After all, mathematics is not all about logic and proof building, but it is also about pattern recognition.

There are two things one should keep in mind: (1) Physics is more than an acrobatic juxtaposition of the latest trends of theoretical jargon; and (2) Mathematics is more than a semiotic game of symbols and operators. In other words, mathematical language is required, but that is not the goal. If one wants to find the light at the end of the tunnel, one should ask different questions and think differently.

A Cat Tied to the Pole

If one wants to find the Holy Grail of Nature, where shall one find the answers? The following story may be helpful:

A long time ago, a Zen teacher in a distant village was disturbed by voice of a cat in his house, so he ordered his students to tie the cat to a pole in the backyard, so he could pray, undisturbed. Decades later, long after the teacher had passed away, all his followers still hold on to their former Zen teachers' exhibited behaviours and have made it into a tradition of tying a cat to a pole in the backyard. They also publish many books discussing the spiritual advantages of praying beside a cat.

That is an old story in a book written by Father Anthony de Mello, a wise priest from India. The lesson is simple but it has deep message: A temporary solution for certain problem can become a cult, worshipped by future generations of ignorant followers.

One may laugh at this story, but let us see four examples to show that the same problem may plague many areas of our modern life:

a. Max Planck. In a desperate move, he used a partition function in order to solve the blackbody paradox. His artificial trick was hailed as quanta of energy by Einstein in his 1905 (photoelectric paper), a development that Planck himself remained sceptical of. The

[5] For interested readers, there are a number of new papers in arXiv which explain this new field of Deep Learning applied to physics, see for instance: J. Thierry-Mieg, https://arxiv.org/pdf/1811.00576.pdf; Dan Guest et al., Annu. Rev. Nucl. Part. Sci. 2018. 68:1–22. url: https://arxiv.org/pdf/1806.11484.pdf; Maziar Raissi, https://arxiv.org/pdf/1801.06637.pdf; Emmanuel de Bezenac et al., https://arxiv.org/pdf/1711.07970.pdf.

photon was then traditionally accepted as real entity by later generations of physicists. In recent years, other physicists prove that Planck's blackbody law can be re-derived by assuming monochromatic waves. Earlier, Timothy Boyer derived Planck's law by applications of stochastic electrodynamics and zero point radiation.[6] Now we ask this question: Does the photon really exist or is it really a "cat tied to a pole" a kind of tradition?

b. Albert Einstein. Einstein developed his general relativity theory with the help of a friend, Marcell Grossmann. He was fully aware that his castle constructions assumed many things, including assumptions of continuous structures. We can argue that it is actually possible to develop various new models of cosmology starting from a discrete space, instead of the "continuous space" assumption. Ask this question: Does space-time curvature physically exist or does it exist only in your mind?

c. Murray Gell-Mann. After spending a few years learning group theory, Gell-Mann developed further Sakata's model, in order to explain certain experimental results which had arisen at the time. He called his extension of Sakata's model, "quark theory". But Gell-Mann himself never considered "quarks" as real entities.[7] They were only his pet name for a mathematical construction. Unfortunately, from that point, Zweig and Yuval Ne'eman developed a theory which assumed "real quarks" in the "cat tied to a pole" tradition. Later on, experimenters realised that quarks cannot be isolated. This realisation points at the fact that "quarks" are merely fictional creatures, based on unquestioned assumptions regarding "the correctness of quarks" in the "tradition" of Gell-Mann. Indeed, there is still a whole subculture in particle physics devoted to the "quark confinement" problem. What is the point of the "quark confinement" problem, if all quarks are just mathematical artefacts in the "tradition" of misunderstanding the origins of the term "quark" as "a particle", rather than a personal term for a mathematical operation, as originally coined by Gell-Mann?

d. Abraham Maslow. He was the "father of humanist psychology" at the time, who was famous for his "hierarchy of needs". Probably you have read that you should fulfil basic human needs first (food, clothes etc.), then begin to meet education and health needs and relationships with others, then seek actualisation of your life. Millions of people followed Maslow's hierarchy advise [5]. The story goes that later in his life, Maslow regretted how his theory was used. Of course, if you think rather deeply, you will find out that if you follow Maslow's recipe, then by the age of 60 you will have no more energy to do actualisation, or to live meaningfully, let alone doing something good for your community. It is much better to do things the other way around: Begin to seek God's purpose in your life, find His Kingdom and His truth, and you will have a purpose in your life. Then gradually God will help you to fulfil all your needs. But unfortunately only a few people

6 See for example, Timothy Boyer, url: https://arxiv.org/abs/physics/0206033; https://arxiv.org/pdf/physics/0605003.pdf; https://arxiv.org/abs/1809.09093; and also O.A. Senatchin, arXiv:physics/0101054.

7 See G. Johnson. **Strange Beauty**: Murray Gell-Mann and the Revolution in Twentieth-Century Physics. url: https://www.amazon.com/Strange-Beauty-Gell-Mann-Revolution-Twentieth-Century/dp/0679756884

can see the way. Most people only follow Maslow's hierarchy blindly, and they forget that is just a hypothesis. That is "*the road less travelled*."

Conclusion: Another Day in Paradise

Perhaps the true purpose of doing mathematics, as well as logic, is to purify our mind. If our mind is like a mirror, then we have to remove all the dust. But minds have limitations too. As Hui Neng[8] put it: "*If there is no shining mirror. …Where can dust collect?"* In other words, while it is true that it takes years to get mathematical mastery in a field, may be the right answer lies somewhere else. Therefore one needs to ask a variety of different questions. Set one's mind free, since "[i]deas are your only currency" [6].

One may learn somewhere that to become a good scientist, one should have great ambition to dominate the entire world. One should be fast like a jaguar, strong like a gorilla, and cruel like a shark. If one follows such an advice, no wonder one gradually become a beast. And that is what they urge one to become in numerous universities. If one is a professor, one is forced to publish 25 papers and maybe more each year. They call it the "*publish or perish*" policy.[9] Actually that is an unnatural draconian "Social Darwinism" policy, while Nature is based on Harmony, caring, and cooperation.

And the plan of Social Darwinism (competition and "survival of the fittest") is to make one's life miserable, like living in constant danger, in a jungle, a policy intended to curtail any real progress in the sciences. No wonder, many leading professors have no time anymore to give lectures, because they are too busy catching up their publication requirements schedule. If one follows this story, this is why scientific productivity in the USA tends to gradually decrease, as a recent article in the Economist magazine reports. See also two other articles cited below[10].

But the truth is, one can do science in entirely different way: Find the *inner peace*, feel the rhythm of your heart, know how much God love you, and begin to love your family and your neighbours. The truth is not out there, but it is inside you. Instead of living like an animal in a jungle, and doing cruel things to one's colleagues, and having even crueller things done to you, try to listen to a soft voice of the Old Friend: "*You can walk with Me in Paradise, right now.*"

Contrary to what most people tell you, "become a mean and cruel animal", or "dominate the whole

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8 Yeno (Hui-neng, 638-713), traditionally considered the Sixth Patriarch of the Zen teaching in China. url: https://www.zinzin.com/observations/2014/zen-in-action-no-tree-no-mirror-no-dust/

9 Eugene Garfield. The Scientist. http://www.garfield.library.upenn.edu/commentaries/tsv10%2812%29p11y19960610.pdf; see also Icy Lee: https://www.cambridge.org/core/journals/language-teaching/article/publish-or-perish-the-myth-and-reality-of-academic-publishing/70454830B619EBF62E0ED9756764748E

10 https://www.focus-economics.com/blog/why-is-productivity-growth-so-low-23-economic-experts-weigh-in; see also https://www.vox.com/new-money/2016/10/24/13327014/productivity-paradox-innovation-growth

world", you can ask: "What is the benefit of dominating the world, if I lose my life? How can I find purpose and happiness?"

In the end, if you seek peace and happiness for you and your neighbours, you will find that you live not in any jungle. Instead, you will find that this day is just another day in Paradise. What we mean by *Deep Science* is:

Deep Learning,
Deep Meaning,
Deep Purpose,
Deep Life,
Deep Spirituality, and
Don't live a superficial life - Go Deep.

To err is human, but to generate original ideas is divine.

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